

## CLAIMS

We claim:

1. A method for reducing mobile hexavalent chromium to non-leachable trivalent chromium in alkaline chromium-contaminated particulate matter or associated pore water, the method comprising the steps of:
  - contacting a source of hexavalent chromium with ferrous ions to produce ferric ions;
  - oxidizing iron pyrite with ferric ions to produce a treatment solution that comprises ferrous sulfate and sulfuric acid, at least a portion of the ferric ions being obtained by microbiological catalytic oxidation of ferrous ions; and
  - contacting the alkaline chromium-contaminated particulate matter or the pore water with the treatment solution for a time sufficient to convert ferrous sulfate into ferric sulfate and to reduce mobile hexavalent chromium to trivalent chromium in the particulate matter,wherein ferrous sulfate produced by oxidizing iron pyrite is a source of ferrous ions in the first contacting step.
2. A method as claimed in Claim 1 wherein the iron pyrite is in fluid communication with the alkaline chromium-contaminated particulate matter or the pore water.
3. A method as claimed in Claim 1 wherein the source of hexavalent chromium is groundwater that comprises hexavalent chromium and wherein the first contacting step comprises the step of contacting the groundwater with ferrous ions to produce a treated groundwater that comprises ferric ions.
4. A method as claimed in Claim 1 wherein the source of hexavalent chromium is a leachate that comprises hexavalent chromium and wherein the first contacting step comprises the step of contacting the leachate with ferrous ions to produce a treated leachate that comprises ferric ions.
5. A method as claimed in Claim 10 wherein the ferric sulfate is a source of ferric ions for the oxidizing step.
6. A method as claimed in Claim 1 wherein the oxidizing step comprises the step of adding exogenous ferric salt to the iron pyrite.

7. A method as claimed in Claim 3, wherein the first contacting step further comprises the step of separating the ferric ions from particulate solids in the treated groundwater.
8. A method as claimed in Claim 1, wherein the iron pyrite is oxidized *ex situ*.
9. A method as claimed in Claim 8, wherein the *ex situ* oxidation is selected from the group consisting of wet oxidation and wet air oxidation.
10. A method as claimed in Claim 1 wherein the oxidizing step comprises the step of contacting the iron pyrite with ferric ions.
11. A method as claimed in Claim 1 wherein the oxidizing step comprises the step of contacting the iron pyrite with a microbiological catalyst.
12. A method as claimed in Claim 11 wherein the microbiological catalyst is an iron-oxidizing bacterium.
13. A method as claimed in Claim 12 wherein the iron-oxidizing bacterium is *Thiobacillus ferrooxidans*.
14. A method as claimed in Claim 1 wherein the oxidizing step comprises the step of passing humid air through the iron pyrite.
15. A method as claimed in Claim 1 wherein the oxidizing step comprises the step of contacting the iron pyrite with a chemical oxidant.
16. A method as claimed in Claim 15 wherein the chemical oxidant is a peroxygen compound.
17. A method as claimed in Claim 16 wherein the chemical oxidant is selected from the group consisting of a peroxide, a persulfate, a permanganate, a perborate, and a percarbonate.

18. A method as claimed in Claim 17 wherein the chemical oxidant is a peroxide selected from the group consisting of hydrogen peroxide, calcium peroxide, and magnesium peroxide.

19. A method as claimed in Claim 1 wherein the mobile hexavalent chromium treated in the method is in particulate matter, the method further comprising the step of increasing the unconfined compressive strength of the particulate matter.

20. A method as claimed in Claim 19 wherein the unconfined compressive strength is increased by adding a low concentration of a pozzalonic material to the particulate matter.

21. A method as claimed in Claim 20 wherein the pozzalonic material is selected from the group consisting of a ground iron slag and a silicate.

22. A method as claimed in Claim 4 wherein the first contacting step further comprises the step of separating the ferric ions from particulate solids in the treated leachate.

23. A method as claimed in Claim 1 wherein the treatment solution has a pH above about 1.

24. A method as claimed in Claim 1 further comprising the step of measuring acid neutralization capacity of the particulate matter or the pore water after contact with the treatment solution.

25. A method as claimed in Claim 1 further comprising, after the step of contacting the particulate matter or the pore water with the treatment solution, the steps of:

disrupting a  $\text{CaSO}_4$  layer formed on the particulate matter in the contacting step to produce disrupted particulate matter; and

contacting the disrupted particulate matter with the treatment solution.

26. A method as claimed in Claim 25 wherein the disrupting step comprises a step selected from the group consisting of shearing, grinding and pulverizing the particulate matter.

27. A method for reducing mobile hexavalent chromium to non-leachable trivalent chromium in alkaline chromium-contaminated particulate matter or associated pore water, the method comprising the steps of:

contacting a source of hexavalent chromium with ferrous ions to produce ferric ions;  
oxidizing iron pyrite with ferric ions to produce a treatment solution that comprises ferrous sulfate and sulfuric acid;

contacting the alkaline chromium-contaminated particulate matter or the pore water with the treatment solution for a time sufficient to convert ferrous sulfate into ferric sulfate and to reduce mobile hexavalent chromium to trivalent chromium in the particulate matter; and

measuring acid neutralization capacity of the particulate matter or the pore water after contact with the treatment solution,

wherein ferrous sulfate produced by oxidizing iron pyrite is a source of ferrous ions in the first contacting step.

28. A method for reducing mobile hexavalent chromium to non-leachable trivalent chromium in alkaline chromium-contaminated particulate matter or associated pore water, the method comprising the steps of:

contacting a source of hexavalent chromium with ferrous ions to produce ferric ions;  
oxidizing iron pyrite with ferric ions to produce a treatment solution that comprises ferrous sulfate and sulfuric acid;

contacting the alkaline chromium-contaminated particulate matter or the pore water with the treatment solution for a time sufficient to convert ferrous sulfate into ferric sulfate and to reduce mobile hexavalent chromium to trivalent chromium in the particulate matter;

disrupting a  $\text{CaSO}_4$  layer formed on the particulate matter in the contacting step to produce disrupted particulate matter; and

contacting the disrupted particulate matter with the treatment solution,

wherein ferrous sulfate produced by oxidizing iron pyrite is a source of ferrous ions in the first contacting step.

29. A method as claimed in Claim 28 wherein the disrupting step comprises a step selected from the group consisting of shearing, grinding and pulverizing the particulate matter.